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SLOW LEARNERS, COMPETITION, AND PROGRAMED INSTRUCTION.

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THE EFFECTS OF TWO POSTULATED COMPETITIVE CONDITIONS ON GROUPS OF RELATIVELY SLOW LEARNERS WERE EXAMINED DURING THE REPORTED RESEARCH. THE TWO COMPETITIVE CONDITIONS WERE--(1) HOMOGENEOUS GROUPING, AS OPPOSED TO HETEROGENEOUS GROUPING AND (2) PUBLIC DISPLAY OF THE PERFORMANCE OF ALL MEMBERS OF A GROUP, AS OPPOSED TO INDIVIDUALIZED FEEDBACK. FOUR GROUPS OF 10 SUBJECTS FROM NINTH-GRADE ALGEBRA CLASSES USED PORTIONS OF "MODERN MATHEMATICS--A PROGRAMED TEXTBOOK, COURSE I" IN THIS STUDY. INSTRUCTION FOR ALL GROUPS WAS AUTOMATED BY SYSTEMS WHICH PRESENTED KNOWLEDGE OF RESULTS. IN TWO OF THE GROUPS, THIS KNOWLEDGE WAS PRESENTED ON A DISPLAY PANEL SO THAT ALL MEMBERS COULD SEE RESULTS FOR THEIR ENTIRE GROUP. IN TWO OTHER GROUPS, STUDENTS RECEIVED PERFORMANCE RESULTS PRIVATELY BY MEANS OF SIGNAL LIGHTS AT THEIR OWN STATIONS. AN ANALYSIS OF VARIANCE OF FIRST POST-TEST SCORES INDICATED THAT HOMOGENEOUS GROUPS SCORED HIGHER THAN THE HETEROGENEOUS GROUPS. THE SIGNIFICANT FINDING WAS THAT HETEROGENEOUS GROUPS RECEIVING PUBLIC DISPLAY OF PERFORMANCE SCORED SIGNIFICANTLY HIGHER GAINS THAN ANY OF THE OTHER GROUPS. OBSERVATION OF THE SUBJECTS DURING THE EXPERIMENT INDICATED THAT GROUPS RECEIVING PUBLIC DISPLAY OF PERFORMANCE INTERACTED AND VERBALIZED CONSIDERABLY, WHILE THOSE RECEIVING PRIVATE KNOWLEDGE DEMONSTRATED VIRTUALLY NONE OF THIS BEHAVIOR. (WB)

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Teaching Research Division
Oregon State System of Higher Education
Monmouth, Oregon

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Problem

The recent development and use of programed instructional material has a two-fold significance for the educational experimenter. First, it offers a means of presenting stimulus materials to students in a manner which permits better control of variables that are significant in research on human learning. Controlling the teacher variable, for example, is a serious methodological problem in much educational research, arising both from variability in teacher behavior and variability in perceptions and expectations held by students relative to the teacher. It is now possible to better control this variable by use of programed instruction techniques and automatic devices. It is reasonable to postulate that experimentation conducted under conditions permitting greater control of relevant variables will lead more directly to understanding and eventually to more effective control of learning and teaching processes.

Also of significance is the molecular nature of programed instruction techniques which permits a more systematic approach to learning problems. Behavioral objectives are specified in considerable detail, and, in the ideal case at least, a painstaking effort is made to make strategic use of learning principles in designing sequences of small instructional steps toward the achievement of the stated objectives. Furthermore, accepted practice in program construction calls for careful and detailed empirical analysis of the learner effects of the program and modification of the program where indicated.

Some instructional programers consider it possible to construct an instructional package that will have predictable effects when used in the intended manner on appropriate learners. One can see a revolutionary

potential here, the beginnings of "instructional engineering."

The realization of this potential will require much more than the development of effective programing techniques. Among other things, it will require more knowledge of the effects of various practices regarding evaluation of student progress, grouping, alterations in social structure, and mode of presentation. Additional knowledge of these and other factors is urgently needed.

One effort in this direction was a study by Frye (1962) in which certain incidental findings inspired the present research. Frye examined the relative effectiveness of pacing students individually and by groups as they worked with a self-instructional program. He found that while a group-paced heterogeneous group did not learn as efficiently as individually paced subjects, a group-paced homogeneous group did. He observed that the much slower learning rate in the heterogeneous group could not be satisfactorily explained only by the ability levels of the slower students because the ability levels of the slower students in both of his experimental groups were remarkably similar.

One explanation for Frye's findings is that when a low-ability student is working with a group of students of comparable ability, he feels more able to play a competitive role than when placed in a group in which some members are much more capable. When forced to compete with more capable students he loses both his desire to compete and his desire to participate in the learning experience. Decrements in participation result in the slower learning rate. Another explanation may be that when a learner perceives himself as less capable than his competitors, he may respond more cautiously. This more deliberate behavior may result in slower performance in the learning task and a slower learning rate.

Frye's findings may have relevance to educators' who are considering the economic and administrative advantages of presenting a single program simultaneously to groups of learners. However, they raise a number of new questions, e.g., what are the motivational effects of competition; what are the essential preconditions of competition; how may these be manipulated to maximize learning benefits and minimize ill effects?

Phenomenologically, situations wherein individuals are striving against each other, for a valued object, are described as competitive. Competitors perceive that the valued object cannot, or should not, be divided equally among them, and that attainment of it is contingent upon some kind of superiority relative to the other competitors.

Expressed in terms of an operant conditioning model, a competitive situation is one in which some response is evoked from each of a number of competitors approaching a reinforcing situation, but the reinforcing stimulus is presented only to the more effective responders. Reinforcement is contingent not only upon the nature of the response of a competitor, but also on the relative effectiveness of his response as compared to those of other competitors. Under these conditions, it is apparent that different competitors may experience different reinforcement schedules and that ineffective competitors may experience little or no reinforcement. It follows that altering the range of ability by different grouping practices may have the effect of practically eliminating reinforcement schedules for some and such grouping practices may have measurable effects on the learning rates of those who are not reinforced.

The experimental application of such a model is made difficult by the fact that the typical educational setting contains a variety of competitive situations and potentially distracting reinforcers. It is

likely that students will compete most actively in those competitive situations that provide the greatest potentiality for reinforcement. The problem, however, in the experimental situation is to create conditions where all participants perceive the situation as a competitive one. In order to examine the effects of competition on learning it is necessary to involve subjects in a competitive effort and provide controlled reinforcement. It is believed that in this research the use of an automated presentation to selected subjects and a unit of programed instruction facilitated these requirements.

Hypotheses

In this study, two conditions define competition:

1. Groups of students are provided with public knowledge regarding the correctness of response of each member to individual program frames.

2. Students are grouped homogeneously with respect to ability in the subject matter.

The effects of these conditions were examined in four groups of students. The groups were differentiated in terms of the presence or absence of the two conditions.

Reinforcement through public, as opposed to private, knowledge of correctness of response gives the reinforcing stimulus a dual significance. It tells the student whether or not he was correct and it informs him of his effectiveness relative to the group. If either of these two items of information are reinforcing, then learning will be enhanced. Knowledge that his response was correct may not be reinforcing to the student, but knowledge that his response was among the correct ones may be reinforcing. Thus there is greater probability of reinforcement of the desired response when knowledge of correctness of response is given

publicly than when each student is informed privately, because there are two factors operating rather than one.

This is not to say that students receiving performance information privately make no inferences from this information as to their relative position in the group. It would be difficult, if not impossible, to determine what qualities of a stimulus make it reinforcing for a given learner. Perceptions of learners must largely be inferred. It is simply argued that public display of the performance of all members presents a stimulus of more complexity, with more reinforcement possibilities, than private presentation.

The postulated reinforcing effect of perceiving one's performance as effective relative to the group, whether this perception is inferred or based on public display of performance, is more likely to occur in groups where other members are of comparable ability than in groups where some members are obviously more capable. In other words, reinforcement is more likely to occur in homogeneous than in heterogeneous groups.

Two criteria will be used to test the hypotheses. In hypotheses 1-8 the criterion is the score made by subjects on the first post-test. In hypotheses 9-16 the criterion is time to completion of a performance criterion.

It is hypothesized that:

1. Low-ability students will score higher on a learning test after having been given knowledge of correctness of their responses and of their performance relative to their group than when given knowledge of correctness of response alone (public vs. private reinforcement).

2. Low-ability students will score higher on a learning test after

learning in a homogeneous group than those learning in a heterogeneous group (homogeneous vs. heterogeneous grouping).

3. Under conditions of heterogeneous grouping low-ability students will score higher on a learning test after having been given knowledge of correctness of their responses and of their performance relative to the group, than when given knowledge of correctness of responses alone (heterogeneous public vs. heterogeneous private).

4. Under conditions of homogeneous grouping low-ability students will score higher on a learning test after having been given knowledge of correctness of their responses and of their performance relative to the group, than when given knowledge of correctness of responses alone (homogeneous public vs. homogeneous private).

5. When given knowledge of correctness of responses privately low-ability students will score higher on a learning test after learning in a homogeneous group, than those learning in a heterogeneous group (homogeneous private vs. heterogeneous private).

6. When given knowledge of correctness of their responses and of their performance relative to the group, low-ability students will score higher on a learning test after learning in a homogeneous group than those learning in a heterogeneous group (homogeneous public vs. heterogeneous public).

7. Low-ability students will score higher on a learning test after learning in a homogeneous group with knowledge of correctness of their responses and knowledge of their performance relative to the group, than those learning in a heterogeneous group receiving knowledge of correctness of their response privately (homogeneous public vs. heterogeneous private).

8. There will be no significant difference between scores on a learning test of low-ability students learning in a homogeneous group and receiving knowledge of correctness of responses privately, and low-ability students learning in a heterogeneous group and receiving knowledge of correctness of their responses and of their performance relative to the group (homogeneous private vs. heterogeneous public).

9. Low ability students will pass a criterion test of performance in less learning time after having been given knowledge of correctness of their responses and of their performance relative to their group, than when given knowledge of correctness of responses alone (public vs. private reinforcement).

10. Low-ability students will pass a criterion test of performance in less learning time after learning in a homogeneous group than those learning in a heterogeneous group (homogeneous vs. heterogeneous grouping).

11. Under conditions of heterogeneous grouping low-ability students will pass a criterion test of performance in less learning time after having been given knowledge of correctness of their responses and of their performance relative to the group, than when given knowledge of correctness of responses alone (heterogeneous public vs. heterogeneous private).

12. Under conditions of homogeneous grouping low-ability students will pass a criterion test of performance in less learning time after having been given knowledge of correctness of their responses and of their performance relative to the group, than when given knowledge of correctness of responses alone (homogeneous public vs. homogeneous private).

13. When given knowledge of correctness of responses privately,

low-ability students will pass a criterion test of performance in less learning time after learning in a homogeneous group than those learning in a heterogeneous group (homogeneous private vs. heterogeneous private).

14. When given knowledge of correctness of their responses and of their performance relative to the group, low-ability students will pass a criterion test of performance in less learning time after learning in a homogeneous group than those learning in a heterogeneous group (homogeneous public vs. heterogeneous public).

15. Low-ability students will pass a criterion test of performance in less learning time after learning in a homogeneous group with knowledge of correctness of their responses and knowledge of their performance relative to the group, than those learning in a heterogeneous group receiving knowledge of correctness of their response privately (homogeneous public vs. heterogeneous private).

16. There will be no significant difference in learning time between low-ability students learning in homogeneous groups and receiving knowledge of correctness of responses privately and low-ability students learning in heterogeneous groups and receiving knowledge of correctness of their responses and of their performance relative to the group (homogeneous private vs. heterogeneous public).

Procedures

Experimental design.

A 2 x 2 factorial design was used, with two levels of reinforcement intensity (high and low) and two levels of reinforcement accessibility (high and low). In the high-intensity condition, subjects are provided with knowledge of the correctness of their response and of the correctness of the responses of the other members of their group. In the low-intensity condition, subjects are provided only with knowledge of the correctness of their own response. High accessibility tc reinforcement is provided by grouping subjects homogeneously, and low accessibility by grouping them heterogeneously.

Reinforcement is knowledge of correctness of response and knowledge of performance relative to group. The general nature of the design is outlined in the following table.

Table I

Experimental Design

Intensity \ Accessibility	High (Homogeneous Group)	Low (Heterogeneous Group)
High (Group knowledge of performance)	N = 10 low ability	N = 10 low ability 10 high ability
Low (Individual knowledge of performance	N = 10 low ability	N = 10 low ability 10 high ability

Intensity of reinforcement was controlled by providing subjects with two kinds of information regarding correctness of their responses. Under the high-intensity condition each subject's performance was automatically reported to the entire group on a display panel. In the low-intensity condition each subject received knowledge regarding only the correctness of his own response.

Accessibility to reinforcement was controlled by the manner in which the groups were constituted. The high-accessibility group consisted of a homogeneous group of low-ability subjects, whereas the low-accessibility group consisted of low-ability members of heterogeneous groups of subjects, i.e., half low and half high-ability. The presence of high-ability subjects in heterogeneous groups reduced the accessibility of reinforcement to low-ability subjects. High-ability subjects served only as environment and no data are reported regarding their performance. Selection of low and high-ability subjects is described below.

Selection of subjects.

A unit of instruction preceeding the material to be used in experimental treatment from a programed algebra course was presented to all students of six different ninth-grade algebra classes at a junior high school, using part of the automatic system used later in the experimental treatment. The program and the equipment are described below. The purpose of this introductory experience was to familiarize potential subjects with programed instruction and with the apparatus to be used in the experiment, and to assure that an adequate number of subjects would have the required prerequisite skills and understandings to participate in the experiment. Class sizes ranged from 20 to 30 students, and a total of about 160 students worked through this preliminary phase of the program.

A screening test was administered to all students at the end of this introductory phase to determine their eligibility in terms of prerequisite knowledge and skills to participate in the experiment. Only those students who demonstrated an ability to solve quadratic equations by factoring and by completing the square, but not by use of the quadratic formula, were considered eligible for participation in the experiment.

Because of scheduling difficulties and the fact that the experiment was being conducted at the end of the year, it was impossible to pool and array the students as originally planned. It was necessary to limit the choice of subjects for each cell to a single class in the case of each homogeneous group, and to two classes for each heterogeneous group. Fortunately, two classes were characterized by relatively low ability levels and these classes supplied the subjects for the homogeneous groups.

Since the experimental design called for a large pool of students from which to select subjects, it was necessary to conduct the experiment at a large school. Unfortunately, contemporary screening practices for algebra courses, now virtually universal in large school systems, drastically reduced the range of student abilities. Advanced students take algebra a year earlier and less capable students are channeled into other mathematics courses. Thus the degree of heterogeneity hoped for in the heterogeneous groups was reduced, and the term "low ability" as used in the hypotheses was applicable only in a relative sense.

Decisions regarding the ability levels of students were made primarily on the basis of their scores on the Orleans Algebra Prognosis Test, with exceptions made where scores were inconsistent with the actual performance of the student in algebra. Since a score on this test is intended as a predictor of algebra success on the basis of pass or fail,

rather than relative standing in algebra achievement, matching students from the different groups was considered unwarranted and an attempt was made rather to equalize group means (Orleans, 1934). In a few cases, where it was necessary to choose between a subject with appropriate ability but no prognosis score and one with an inappropriate prognosis score, the decision was made in favor of the subject with no score. The other criterion used was the algebra performance demonstrated by the subjects prior to the experiment.

The two homogeneous groups were composed of the ten students of lowest ability to pass the screening test in each of two classes. For each heterogeneous condition it was necessary to use subjects from two classes, five high and five low-ability students from each class, in order to obtain data on ten low-ability students for each cell of design. Mean Orleans Algebra Prognosis scores of the low-ability students in the two heterogeneous groups were quite comparable, as were the scores of the high-ability students in these groups. Mean scores of the two homogeneous groups were identical but there were unavoidable differences between the homogeneous and heterogeneous group means (group means were intended to be comparable) due to the limited choice of subjects in the homogeneous groups.

Instructional program.

Two chapters of a linear Skinnerian-type program (Eigen, Kaplan, Emerson and Krouse, 1962) were used, with the response mode changed from constructed response to selected response, to make possible automatic feedback to students regarding correctness of their response. The first chapter was used for the introductory phase and the second for the experimental phase of the experiment. Where a frame had originally called

for a multiple response, it was divided so that there would be a single selected response for each frame presented. When appropriate, the first stimulus and correct response would be repeated on subsequent frames derived from the same original frame. Each frame was typed on a separate card with a primer typewriter, photographed, and made into a negative (white on black) slide. In the published program the two chapters used contained 84 and 97 frames. As modified for this experiment, they consisted of 105 and 135 frames, respectively. In addition, where the program had supplemented the feedback with an explanation, this information was presented to the subjects on a separate slide.

Equipment.

A display panel (Figure 1) was constructed for use with the groups receiving public knowledge of performance. (Appendix A contains schematic diagram of display panel.) The names of subjects were placed on translucent plates of plexiglas and inserted in the display panel. Behind each panel was a red light and a clear light. Selection of a correct response by a student would lead to the illumination of his name on the panel with a white background. Selection of an incorrect response would lead to illumination of his name with a red background. (Appendix B describes modifications of Edex system.)

A taped program was prepared to operate an Edex Teaching System automatically (Figure 2). The system controlled the presentation of the slides, automatically keyed the correct response, evaluated the response of each student, controlled the presentation of feedback on the display panel, and advanced to the next frame. Automatic frame advance was accomplished by the "D-Release" feature of the Edex Teaching System. Each student had a response box with four buttons, "A", "B", "C", and "D".

No frame in the program had more than three response alternatives, so only the "A", "B" and "C" buttons were required for any response. Each frame cycle would begin with the instruction to the students to depress the "D" button. Then they would read the frame and make a response. When all students had responded, no D-button would remain depressed and the system would automatically illuminate the display panel and simultaneously advance to the next frame. The display panel would stay lighted long enough for each student to observe his own results and those of the rest of the group, slightly less than ten seconds, but no student needed to wait for the presentation of the next slide.

The groups receiving private knowledge of results received the same instructional program with certain necessary modifications in the response system. A Corrigan Teletest system was used to collect responses and give private knowledge of performance. The student stations (Figure 3) were comparable to those of the Edex System, except that each student station contained a small window behind which was a red and a green light indicating incorrect or correct responses respectively. The lights also had different shapes for the benefit of color-blind students, a contingency provided for by light intensity in the Edex mode.

While the Corrigan system provided for answer keying by the teacher, (Figure 4) it was not automatic, nor was the frame advance, so this was done manually by the instructor. It was necessary to provide an auxiliary system to determine when all students had completed a frame; a simple series of switches, one for each student, that would illuminate a neon light to signal the investigator to advance to the next frame (Figure 4; Appendix contains schematic diagram). A typical frame cycle would consist of the presentation of the frame on the screen, an

indication from the students that all were finished, keying of the correct response by the investigator, response by the student depressing a button at his station, illumination of the feedback light, and presentation of the next frame. The next frame was actually available to the students about two seconds after the investigator received the signal that all students had completed the frame.

With respect to time lapse between completion of one frame and commencing the next, the only difference between the public and private knowledge groups was that members of the public knowledge groups could elect to spend a few seconds scanning the display panel, but they were not forced to do so.

Criteria.

As previously mentioned, a screening test was constructed to determine the ability of potential subjects to solve quadratic equations by factoring and completing the square, but not by using the quadratic formula. (Appendix D.)

Four parallel forms of a post-test were prepared in order to eliminate practice-effect errors from those who were required to review the program and repeat the test. The test was designed to measure the degree of attainment of the instructional objectives. These abilities were measured:

1. Identifying standard form of quadratic equations.
2. Transforming quadratic equations into standard form.
3. Discriminating between quadratic and other equations.
4. Constructing the quadratic formula as the solution set of $ax^2 + bx + c = 0$.
5. Solving three problems of increasing complexity using the quadratic formula.

In scoring the quadratic formula problems, partial credit was given for correctly done parts that would lead to a correct solution. The first post-test score served as one criterion, and time to completion of a performance standard of working two quadratic formula problems correctly was the second criterion. (Appendix E.)

Although not called for in the original experimental design, a semantic differential instrument was prepared for before and after administration. It was felt that the rationale which generated the initial hypotheses implied an affective component to the behavioral changes predicted, and that such an instrument might be of value in interpreting results. (Appendix F.)

Data collection.

The experiment was conducted in a high school adjacent to the junior high school from which the subjects were selected. The classroom used was large enough to allow complete illumination of a 60" x 60" projection screen.

The two classes forming the heterogeneous public knowledge cell met during the second and seventh periods of the school day. Those forming the heterogeneous private knowledge cell met during the third and fourth periods. The homogeneous private knowledge group met during the sixth period and the homogeneous public knowledge group during the eighth period. In each case the subjects were participating in the experiment at the same time that they would ordinarily be in their regular algebra class. There were few absences, but make-up periods were provided as needed during the first and fifth periods and after school. An accurate record of the time in minutes spent by each group on the program was kept by the investigator. The investigator also kept an anecdotal record of

incidents occurring during the course of the experiment that might influence the findings and observations that might aid in interpreting the findings.

As each group completed the program, a post-test was administered. Data were collected on two criteria: (1) score on the first post-test, and (2) time required to achieve a proficiency demonstrated by completing two problems correctly in a given test using the quadratic formula. Subjects who met the latter criteria were excused after completing a semantic differential form. Other subjects went through the program a second time. In each group it was necessary to start the program at the first frame, since at least one member was unsure of the early material.

Due to shortness of time before the end of the school year, it was deemed advisable to abbreviate the second administration of the program, eliminating the terminal frames occurring after frame 78 of the published version of the program. On completion of the second administration of the program, subjects were tested again. Those still not passing the criterion were started a third time, this time each group working through frames 38 to 66 of the program. Six of the subjects failed the third test and another was absent, but no more time was available and it would be difficult to project how long the remaining subjects would have needed to satisfy the criterion.

Statistical analysis.

Analysis of variance was used to test hypotheses 1, 2, 9 and 10. Analysis of covariance was used to determine the influence of Orleans Algebra Prognosis Test scores on first post-test scores. Individual cells representing the four possible combinations of conditions were compared using t-tests to test hypotheses 3-8 and 11-16. T-tests were also

used to compare gain scores of the four groups on the semantic differential.

Results

Analysis of first post-test scores.

Table II summarizes mean scores of the total sample on the first post-test. Significance of differences between individual groups was determined by t-tests. An analysis of variance of post-test scores for

Table II

Mean Scores of Total Sample on First Post-test

Intensity \ Accessibility	High (Homogeneous Group)	Low (Heterogeneous Group)	Difference
High (Group knowledge of performance)	59.8	41.6	18.2[a]
Low (Individual knowledge of performance)	42.0	27.1	14.9[b]
Difference	17.8[a]	14.5	

[a] Statistically significant $p < .02$

[b] Statistically significant $p < .05$

the total sample was done and is summarized in Table III. As noted previously, mean Orleans Algebra Prognosis Test scores were higher in the homogeneous (high-accessibility) groups than in the heterogeneous (low-accessibility) groups. Since the results of an analysis of variance indicated a significant difference between these groups (Table IV), a post-test analysis of covariance using the OAP score as the concomitant

Table III

Analysis of Variance of Post-test Scores for Total Sample

Source of Variation	d.f.	Sums of Squares	Mean Square	F
Accessibility	1	2739.025	2739.025	7.890**
Intensity	1	2608.225	2608.225	7.514**
Interaction	1	27.225	27.225	--
Within	36	12496.900	347.136	
Total	39	17871.375		

** $P < .01$

Table IV

Analysis of Variance of OAP Scores -- Corrected for Disproportionate Subclass Frequencies

Source of Variation	d.f.	Sums of Squares	Mean Square	F
Accessibility	1	723.916	723.916	8.516**
Intensity	1	23.133	23.133	
Interaction	1	21.672	21.672	
Within	31	2635.239	85.008	
Total	34	3403.960		

** $P < .01$

variate was performed. These results are summarized in Table V. Sample size was attenuated by absence of OAP scores for some subjects, and further attenuated by the necessity of randomly eliminating subjects to equalize groups. An analysis of variance of post-test scores of this attenuated sample is summarized in Table VI. Discrepancies between significance reported in Table III and Tables V and VI are a result of attenuation of the sample, not of the influence of OAP scores. A summary of OAP, post-test, and time scores of subjects in each group is found in Appendix G.

Analysis of time scores.

It appears that the use of time scores as a criterion was not appropriate for this experiment. Variability of time scores within groups was of such size as to virtually preclude significant findings. Mean time scores of the four groups are reported in Table VII. An analysis of variance of time scores is summarized in Table VIII. All F scores were below unity. The sample was attenuated due to subjects not passing the criterion test and equalization of groups.

There was also a sizeable within group variation in gain scores on the semantic differential, and the only significant finding ($p < .05$) was that the heterogeneous, public display (low-accessibility, high-intensity) group scored higher than the other three groups.

The lack of significant differences between groups with respect to time required to reach a criterion of performance indicates the rejection of all hypotheses relating to time, i.e., hypotheses 9-15. Since this criterion was considered to be insensitive to whatever differences did occur, any test of hypothesis 16 is inappropriate.

Table V

Tests of Significance Resulting from Analysis of Covariance of Post-test Scores with Control for OAP Scores

Source of Variation	d.f.	Residual Sums of Squares	Mean Square	F
Accessibility	1	2,001.471	2,001.471	5.163*
Intensity	1	1,120.751	1,120.751	2.891
Interaction	1	28.756	28.756	--
Within	28	10,853.161	387.612	

* $P < .05$

Table VI

Analysis of Variance of Post-test Scores for Sample Attenuated for Covariance Analysis

Source of Variation	d.f.	Residual Sums of Squares	Mean Square	F
Accessibility	1	2,113.117	2,113.117	5.373*
Intensity	1	1,225.125	1,225.125	3.367
Interaction	1	39.883	39.883	--
Within	28	11,012.750	393.313	
Total	31	14,390.875		

* $P < .05$

Table VII

Mean Time to Completion of Performance Criterion

Intensity \ Accessibility	High (Homogeneous Group)	Low (Heterogeneous Group)	Difference
High (Group Knowledge of Performance)	312.8	281.1	31.7
Low (Individual Knowledge of Performance)	295.7	288.3	7.4
Difference	17.1	7.2	

Table VIII

Analysis of Variance of Time Scores for Attenuated Sample

Source of Variation	d.f.	Residual Sums of Squares	Mean Square	F
Display	1	1,056.571	1,056.571	---
Group	1	8,494.214	8,494.214	---
D X G	1	174.887	174.887	---
Within	24	2,212,387.042	94,218.279	---
Total	27	2,222,112.714		

With respect to those hypotheses dealing with post-test scores:

Hypothesis 1. Analysis of variance of the total sample (Table III) indicates that subjects did score higher on a learning test after having been given knowledge of correctness of their responses and of their performance relative to the group than subjects given knowledge of correctness of responses alone. Analysis of covariance with control for OAP scores required attenuation of the sample and differences between the attenuated groups with respect to this hypothesis were not significant (Tables V, VI). Thus data from the total sample support the hypothesis, while data from the attenuated groups do not.

Hypothesis 2. Subjects learning in homogeneous groups did score higher on a learning test than subjects in heterogeneous groups. Results of analysis of variance and analysis of covariance (Tables III, V) substantiate the hypothesis.

Hypothesis 3. Under conditions of heterogeneous grouping, the differences found between subjects given knowledge of correctness of their responses and of their performance relative to the group, and subjects given knowledge of correctness of responses alone, did not reach the .05 level of significance ($t = 1.622$). The hypothesis is rejected.

Hypothesis 4. Under conditions of homogeneous grouping, subjects did score higher on a learning test after having been given knowledge of correctness of their responses and of their performance relative to the group, than subjects given knowledge of correctness of their responses alone. Results of a t-test for significance substantiate the hypothesis (Table II, $t = 2.318$, $p < .02$).

Hypothesis 5. When given knowledge of correctness of responses privately, subjects in a homogeneous group scored higher than subjects

in a heterogeneous group. Results of a t-test substantiate the hypothesis (Table II, $t = 1.754$, $p < .05$).

Hypothesis 6. When given knowledge of correctness of their responses and of their performance relative to the group, subjects in a homogeneous group scored higher than those in a heterogeneous group. Results of a t-test substantiate the hypothesis (Table II, $t = 2.111$, $p < .02$).

Hypothesis 7. Subjects in a homogeneous group with knowledge of correctness of their responses and knowledge of their performance relative to the group, scored higher on a learning test than subjects in a heterogeneous group receiving knowledge of correctness of their response alone. Results of a t-test substantiate the hypothesis (Table II, $t = 6.709$, $p < .001$).

Hypothesis 8. There were no significant differences between scores on a learning test of subjects learning in a homogeneous group and receiving knowledge of correctness of response privately, and subjects in a heterogeneous group receiving knowledge of correctness of their responses and of their performance relative to the group (Table II, $t = .037$).

Although not directly related to the hypotheses with which this study is concerned, certain other behavioral outcomes of the experimental treatment should be noted here.

The investigator's anecdotal record of incidents occurring during the course of the experiment provides some additional information on the effects of competitive situations. On the first day of the treatment it was noted that the three classes composing the two low-intensity (private knowledge) groups "sat transfixed and silent--no interaction," during the treatment sessions. Some unsolicited comments from members of these groups were: "It's easier to concentrate when you know you have to

answer," "People aren't always talking."

In contrast, the groups receiving public knowledge of results demonstrated a considerable amount of overt verbal behavior, such as teasing of persons making errors and sighs of relief or disgust. They made comments like, "See, I knew I missed it!" and "Hooray!" On at least two occasions a cheer was emitted when the whole group made correct answers.

The occurrence of this contrasting behavior presented a problem to the investigator, as to which would have the more detrimental effect upon the experiment -- restraining the students and therby reintroducing, in effect, the teacher variable, or permitting the behavior, realizing that this also might influence the results. Since the behavior seemed to be an outgrowth of the mode of giving knowledge of results, it was decided to permit it to continue.

Interestingly enough, the contrast did continue to the end of the experiment. Repeated reference was made anecdotally to the "almost hypnotic behavior" of the private-knowledge groups, and in the public-knowledge groups virtually every frame was punctuated with sighs, groans, cheers, and comments like, "What's the matter, Ken?" or "I got it right."

On a few occasions, in both the public and private-knowledge groups, the knowledge of results mode was improperly keyed, giving students erroneous information regarding their answers. When this was noted and corrected the private-knowledge groups demonstrated no more than a sigh of relief. In public-knowledge groups erroneous feedback caused much distress, and members displayed what the investigator interpreted as "thinly veiled hostility." With respect to public-knowledge groups, the the investigator also had the feeling, admittedly impossible to verify,

that high-ability students were, on occasion, deliberately giving incorrect answers. Also observed in the public-knowledge groups was a tendency of the more successful students to "tutor" others during the program presentation.

Discussion

The apparent contradiction of post-test results and time score results may be resolved in two ways. One could postulate the existence of separate learning curves for the different treatment groups. Thus the findings could be interpreted as indicating that certain conditions which have been defined here as competitive, have certain transitory beneficial effects that are revealed in the early stages of a learning experience. Apparently these advantages disappear by the time mastery of the subject matter is attained.

Uniformity at the terminus of the learning curves could indicate that the motivating effects of competition, while still present, do not continue to enhance performance because of some emerging inhibitory factor or because of the absence of some necessary facilitating factor.

Such uniformity could also indicate that after a period of time competitive situations, as they have been defined here, actually cease to be competitive. It is possible that once a learner has established his position in a group, feedback regarding relative position in the group is no longer of vital importance, and ceases to be an issue.

Further, while homogeneity of groups initially may arouse a broader and more intense striving for position than heterogeneity, once these positions have been established the reinforcing effect of group knowledge of performance may tend to broaden in its scope of effectiveness to include virtually all learners who experience any success at all.

For example, once all the learners in a heterogeneous group have acquired stable perceptions of their relative effectiveness in a group, the less capable learners may be as effectively reinforced by the variable interval reinforcement of equaling or excelling the more capable learners, as the more capable ones are by the fixed interval reinforcement schedule of consistently being told they excel.

To some extent, the foregoing discussion rests on the assumption that both of the criterion measures were valid. Another explanation of their inconsistency could be that the time scores, which yielded no significance between groups, were inappropriate in their application here and did not accurately measure existing variations in performance. There are some strong arguments for accepting this view.

First, much of the variability in time scores within groups was a consequence of the design. Where it had been hoped that there would be some variation between groups regarding the starting point for the second administration of the program, the relative difficulty of the program for these learners, and the presence of low-ability subjects in every group, necessitated starting all groups at the beginning the second time.

Further, all subjects not passing the first test had to go through the second administration completely, no matter how close to passing their first test performance had been. Subjects did not have an option to try the test again when they felt prepared, as this would not have been feasible in the design. Thus, many subjects may have been forced to spend time in the program after they could have passed the performance test.

This investigator believes that while the effects of competition may have diminished somewhat during the course of the experiment, for

the reasons advanced above, results indicated by time scores do not warrant the conclusion that the four conditions are equally efficient because, in the investigator's opinion, the criterion was relatively insensitive to whatever differences did exist.

While post-test results tended to support the hypotheses, certain precautions should be observed in interpreting these findings. First, although public display of performance was more effective with the homogeneous than the heterogeneous group, it does not follow that the heterogeneous group was demoralized or discouraged. One might expect this effect when low ability learners are competing with those of higher ability, but the semantic differential indicated significantly higher gains in the heterogeneous group. Whatever undesirable effects competition may have had on this group, negative attitudes toward algebra were not among them.

Second, while the results indicate that public display of performance enhances learning, the marked difference in behavior between public and private display groups should be recalled. Public display seemed to generate a high level of nervous excitement and occasionally hostility. If public display of knowledge of performance arouses unintended and unpredictable behaviors from students, the predictability of learning effects may be lost or greatly reduced. If controlled and predictable student behavior is desired, it may be that this mode of giving knowledge of performance should be avoided until its effects are better understood.

Third, the term "slow learners," as it has been used here, means students of average ability working with those of high ability, and thus "slow" only in a relative sense. Every subject participating was receiving passing grades (C - or higher) in algebra. Thus a slow-learner

syndrome of low achievement motivation, negative attitude, and poor study habits did not characterize these subjects. Generalization of these findings to situations involving retarded or unmotivated students does not appear to be warranted.

While the evidence reported in this pilot study seems to indicate that in a competitive situation, learning is enhanced for all "low-ability" students by increasing intensity and accessibility of reinforcement, further study seems warranted regarding means of maintaining the competitive condition over prolonged periods of time without undesired social effects, other means of regulating reinforcement intensity and accessibility and other dimensions of competition that may be examined experimentally and used educationally.

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Appendices

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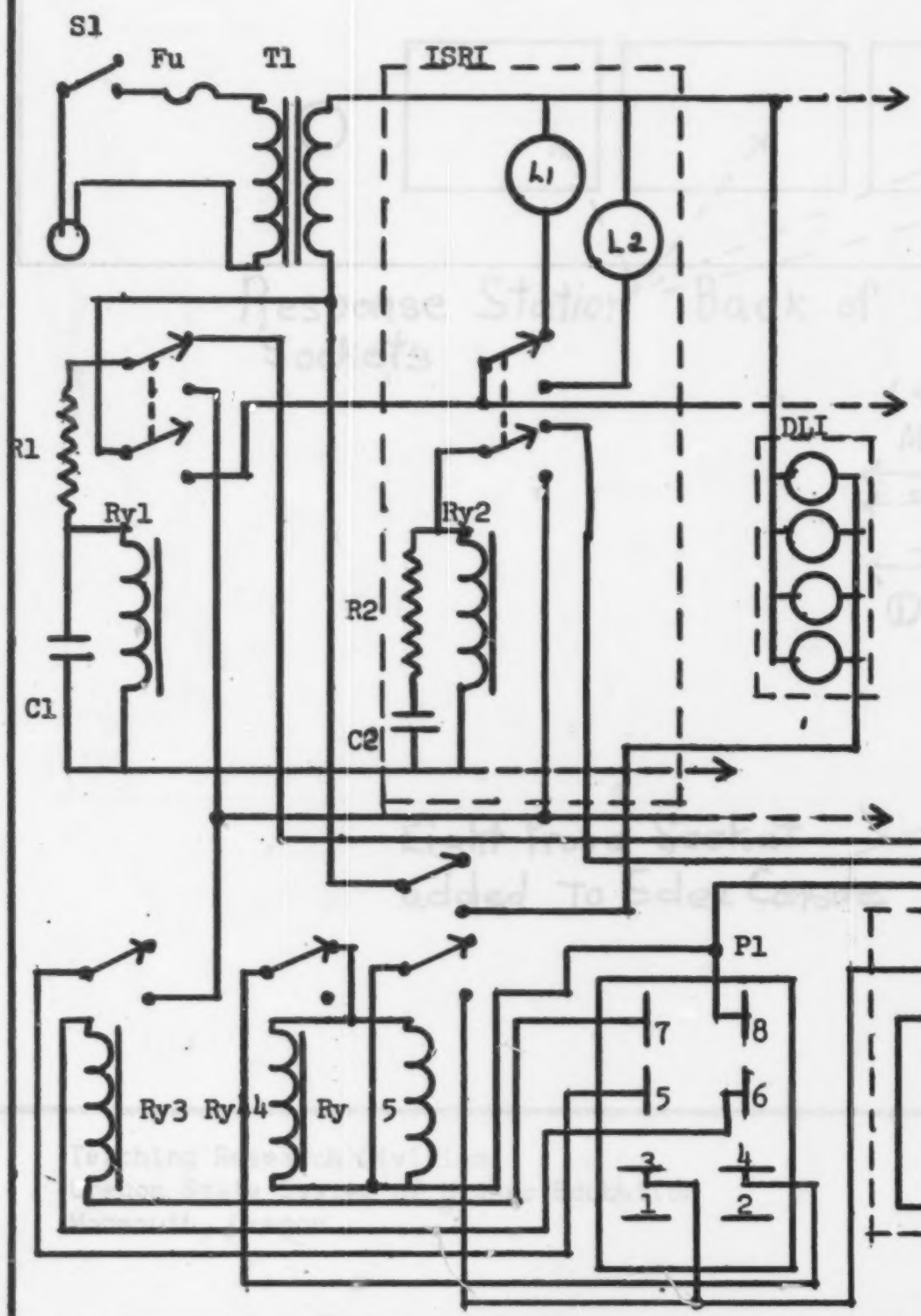
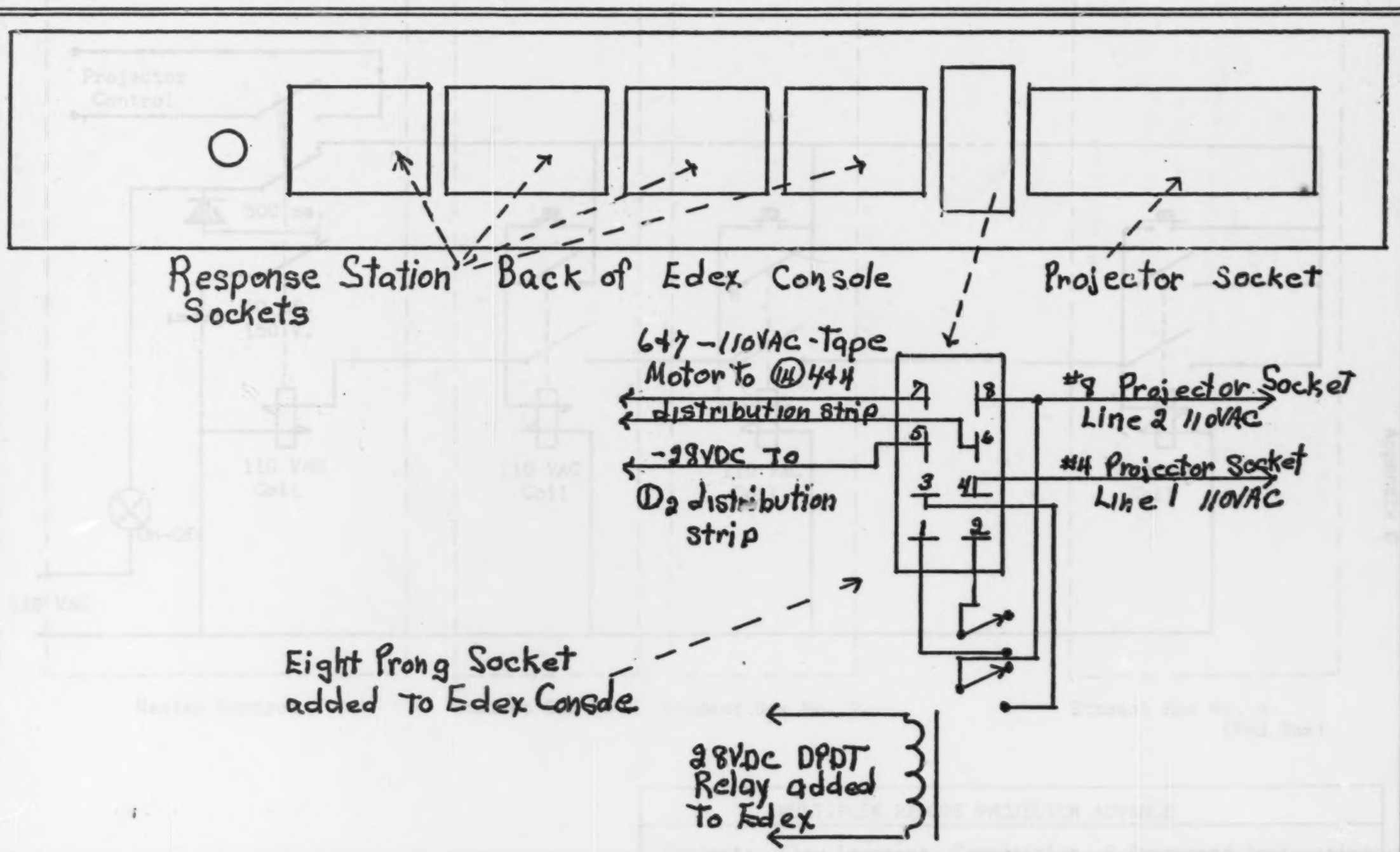
Legend: Response Indicator

S1	On and off switch - SPST 3 amp rating
Fu	Fuse 5/8 amp rating
R1	220 ohm, ½ watt resistor
R2-N	120 ohm, ½ watt resistor
Ry 1, 2-n	24V DC relay, DPDT, 5 amp contacts
Ry 3	24V DC relay, DPDT, 5 amp contacts
Ry 4	Amperite delay relay, 5 second, 115C5
Ry 5	110V AC relay, 4PDT, 5 amp contacts
Ry Ex	24V DC relay, DPDT, 5 amp contacts mounted in Edex console, with diode and capacitor to operate from the 24V AC supplied from the control circuit power winding in the Carousel slide projector
Ds	500 ma, 200 PIV, silicon diodes
C1, 2, N	5 mfd, 50 WVDC electrolytic capicitor
P1	Adaptor plug to fit socket on back of Edex console
P2	Adaptor plug to fit student station socket on Edex console
ISRI	Individual Student Response Indicator - one for each student - one red and one white light
DLI	D Button Light Indicator - 4 white lights (D lights and ISRI lights are #44 pilot lights)
C1, 2, N	5 mfd 50 WVDC electrolytic capacitor
T1	6.3V AC 3 amp filament transformer

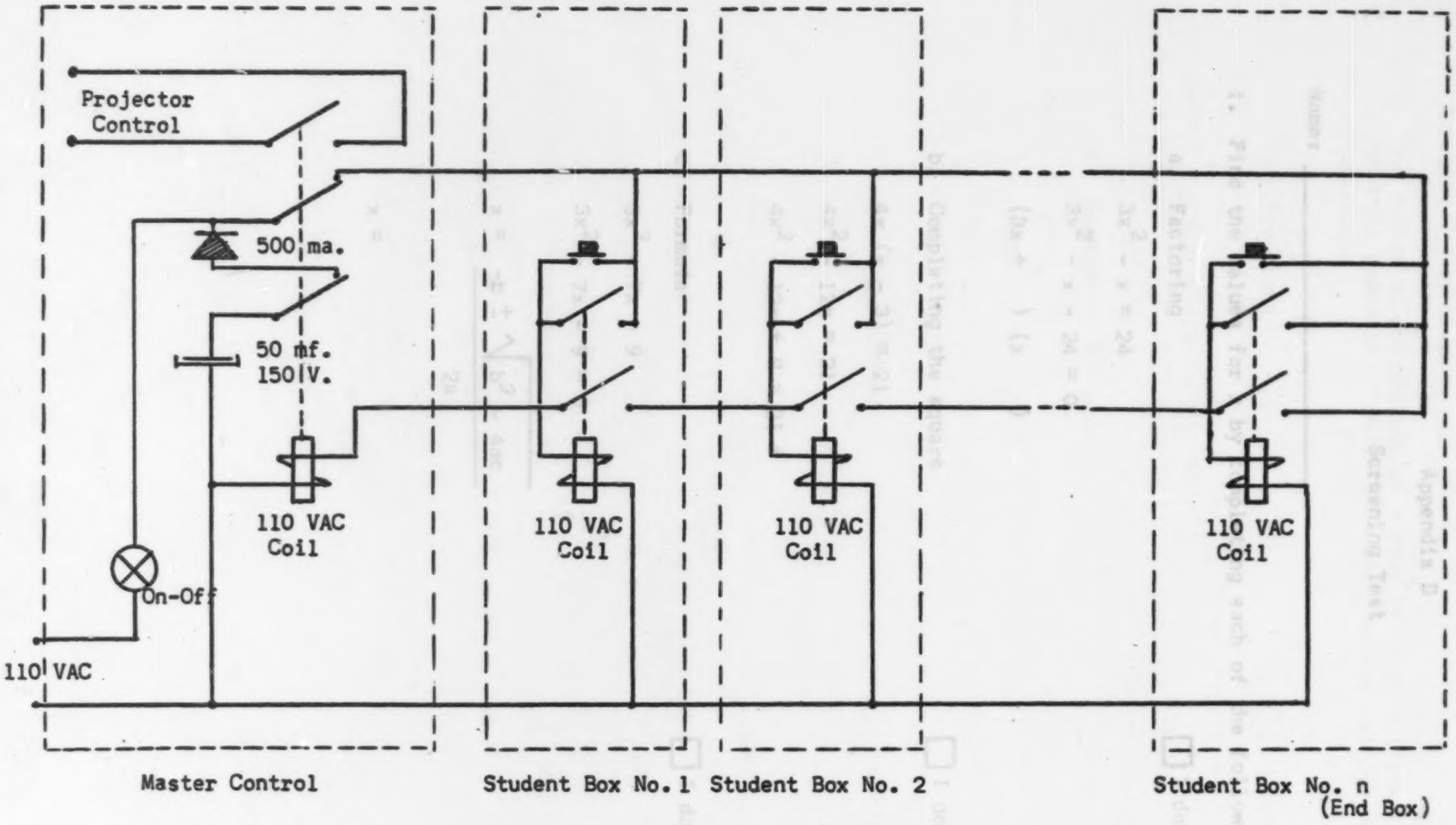


RESPONSE INDICATOR	
Project: Slow Learners, Competition, & Programed Instruc.	
NDEA VII - 7-47-0000-221	Date: June 15, 1964
Rodney Steen	Teaching Research Div. OSSHE



Teaching Research Division
Oregon State System of Higher Education
Monmouth, Oregon

Edex Console Modifications
Drawn by Rodney Steen



MULTIPLEX REMOTE PROJECTOR ADVANCE	
Project: Slow Learners, Competition, & Programed Instruction	
NDEA VII - #7-47-0000-221	June 15, 1964
Charles Frye	Teaching Research Div., OSSHE

Appendix D

Screening Test

Name: _____

1. Find the values for x by completing each of the following problems.

   a. Factoring ☐ I don't know how.

   $3x^2 - x = 24$

   $3x^2 - x - 24 = 0$

   $(3x + \quad)(x \quad)$

   b. Completing the square ☐ I don't know how.

   $4x(x - 3) = 21$

   $4x^2 - 12x = 21$

   $4x^2 - 12x + 9 = 21 +$

   c. Formula ☐ I don't know how.

   $3x^2 - 7x - 9$

   $3x^2 - 7x - 9 = 0$

   $$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

   $x =$

(Appendix D - continued)

2. The following problem can be solved by three different methods. Show the complete solution using each method with which you are familiar.

$$x^2 + 8x = 20$$

a. Factoring ☐ I don't know how.

b. Completing the square. ☐ I don't know how.

c. Quadratic Formula ☐ I don't know how.

3. Solve this equation for x. ☐ I don't know how.

$$wx^2 + yx + z = 0$$

Appendix E

Sample Form of Post-test

Name: _____

I. Some of the following quadratic equations are in standard form and some are not. Change those that are not in standard form to equivalent equations that are.

$3 + 4y = -y^2$ _____ = _____

$2w^2 + 4w - 1 = 0$ _____ = _____

$8z^2 + 3z + 5 = 0$ _____ = _____

$x\ (x + 4) = -4$ _____ = _____

II. Which of the following equations are quadratic equations?

a. $2x^3 + 3x^2 + 1 = 0$ Yes No

b. $3z^2 + 2z + 3 = 0$ Yes No

c. $y\ (y - 1) = -1$ Yes No

d. $wz = 6$ Yes No

III. Solve using the quadratic formula: $x^2 + 3x + 2 = 0$

IV. Solve using the quadratic formula: $3y^2 - 4y + 1 = 0$

V. Solve using the quadratic formula: $z^2 = 2\ (2z - 1)$

VI. Solve using the quadratic formula: $ax^2 + bx + c = 0$

Appendix F

Semantic Differential

Instructions:

The purpose of this study is to measure what certain words and mathematical symbols mean to various people by having them judge them against a series of descriptive scales. In rating the scales that follow, please make your judgments on the basis of what these words and symbols mean to you. On the following pages of this questionnaire are the words and symbols to be rated, and beneath them a set of scales. You are to rate these words and symbols on each of these scales in order.

Here is how you are to use these scales:

If you feel that the word you are rating is <u>very closely related</u> to one end of the scale, you should place your checkmark as follows:

fair __X__:_____:_____:_____:_____:_____:_____ unfair

or

fair _____:_____:_____:_____:_____:_____:__X__ unfair

If you feel that the word is <u>quite closely related</u> to one or the other end of the scale (but not extremely), you should place your checkmark as follows:

strong _____:__X__:_____:_____:_____:_____:_____ weak

or

strong _____:_____:_____:_____:_____:__X__:_____ weak

If the word seems <u>only slightly related</u> to one side as opposed to the other side (but is not really neutral), then you should check as follows:

active _____:_____:__X__:_____:_____:_____:_____ passive

or

active _____:_____:_____:_____:__X__:_____:_____ passive

The direction toward which you check, of course, depends upon which of the two ends of the scale seem most characteristic of the thing you're judging.

If you consider the word to be <u>neutral</u> on the scale, both sides of the scale <u>equally associated</u> with the word, or if the scale is <u>completely irrelevant</u>, unrelated to the word, then you should place your checkmark in the middle space:

safe _____:_____:_____:__X__:_____:_____:_____ dangerous

IMPORTANT: (1) Place your checkmarks <u>in the middle of spaces</u>, not on the boundaries:

(Continued on next page)

Semantic Differential - continued.

	THIS				NOT THIS	
	X				X	

(2) Be sure you check every scale.

(3) Never put more than one checkmark on a single scale.

Sometimes you may feel as though you've had the same item before in the test. This will not be the case, so do not look back and forth through the items. Do not try to remember how you checked similar items earlier in the test. Make each item a separate and independent judgment. It is your first impressions, the immediate "feelings" about the items, that we want. On the other hand, please do not be careless because we want your true impressions.

Teaching Machines

Good							Bad
Cruel							Kind
Painful							Pleasurable
Successful							Unsuccessful
High							Low
Meaningless							Meaningful
Important							Unimportant
Ugly							Beautiful
Hopeful							Hopeless
Graceful							Awkward

Factoring

Good	_____:_____:_____:_____:_____:_____:_____	Bad
Cruel	_____:_____:_____:_____:_____:_____:_____	Kind
Painful	_____:_____:_____:_____:_____:_____:_____	Pleasurable
Successful	_____:_____:_____:_____:_____:_____:_____	Unsuccessful
High	_____:_____:_____:_____:_____:_____:_____	Low
Meaningless	_____:_____:_____:_____:_____:_____:_____	Meaningful
Important	_____:_____:_____:_____:_____:_____:_____	Unimportant
Ugly	_____:_____:_____:_____:_____:_____:_____	Beautiful
Hopeful	_____:_____:_____:_____:_____:_____:_____	Hopeless
Graceful	_____:_____:_____:_____:_____:_____:_____	Awkward

Teaching Machines

Good	_____:_____:_____:_____:_____:_____:_____	Bad
Cruel	_____:_____:_____:_____:_____:_____:_____	Kind
Painful	_____:_____:_____:_____:_____:_____:_____	Pleasurable
Successful	_____:_____:_____:_____:_____:_____:_____	Unsuccessful
High	_____:_____:_____:_____:_____:_____:_____	Low
Meaningless	_____:_____:_____:_____:_____:_____:_____	Meaningful
Important	_____:_____:_____:_____:_____:_____:_____	Unimportant
Ugly	_____:_____:_____:_____:_____:_____:_____	Beautiful
Hopeful	_____:_____:_____:_____:_____:_____:_____	Hopeless
Graceful	_____:_____:_____:_____:_____:_____:_____	Awkward

√

Good	_____:_____:_____:_____:_____:_____:_____	Bad
Cruel	_____:_____:_____:_____:_____:_____:_____	Kind
Painful	_____:_____:_____:_____:_____:_____:_____	Pleasurable
Successful	_____:_____:_____:_____:_____:_____:_____	Unsuccessful
High	_____:_____:_____:_____:_____:_____:_____	Low
Meaningless	_____:_____:_____:_____:_____:_____:_____	Meaningful
Important	_____:_____:_____:_____:_____:_____:_____	Unimportant
Ugly	_____:_____:_____:_____:_____:_____:_____	Beautiful
Hopeful	_____:_____:_____:_____:_____:_____:_____	Hopeless
Graceful	_____:_____:_____:_____:_____:_____:_____	Awkward

Programed Learning

Good	_____:_____:_____:_____:_____:_____:_____	Bad
Cruel	_____:_____:_____:_____:_____:_____:_____	Kind
Painful	_____:_____:_____:_____:_____:_____:_____	Pleasurable
Successful	_____:_____:_____:_____:_____:_____:_____	Unsuccessful
High	_____:_____:_____:_____:_____:_____:_____	Low
Meaningless	_____:_____:_____:_____:_____:_____:_____	Meaningful
Important	_____:_____:_____:_____:_____:_____:_____	Unimportant
Ugly	_____:_____:_____:_____:_____:_____:_____	Beautiful
Hopeful	_____:_____:_____:_____:_____:_____:_____	Hopeless
Graceful	_____:_____:_____:_____:_____:_____:_____	Awkward

$$x = \frac{-b \pm \sqrt{b^2 - 4ac}}{2a}$$

Good	____:____:____:____:____:____:____	Bad
Cruel	____:____:____:____:____:____:____	Kind
Painful	____:____:____:____:____:____:____	Pleasurable
Successful	____:____:____:____:____:____:____	Unsuccessful
High	____:____:____:____:____:____:____	Low
Meaningless	____:____:____:____:____:____:____	Meaningful
Important	____:____:____:____:____:____:____	Unimportant
Ugly	____:____:____:____:____:____:____	Beautiful
Hopeful	____:____:____:____:____:____:____	Hopeless
Graceful	____:____:____:____:____:____:____	Awkward

Algebra

Good	____:____:____:____:____:____:____	Bad
Cruel	____:____:____:____:____:____:____	Kind
Painful	____:____:____:____:____:____:____	Pleasurable
Successful	____:____:____:____:____:____:____	Unsuccessful
High	____:____:____:____:____:____:____	Low
Meaningless	____:____:____:____:____:____:____	Meaningful
Important	____:____:____:____:____:____:____	Unimportant
Ugly	____:____:____:____:____:____:____	Beautiful
Hopeful	____:____:____:____:____:____:____	Hopeless
Graceful	____:____:____:____:____:____:____	Awkward

Appendix G

Summary of Subject Data in Four Experimental Groups

Public Display Homogeneous Group

OAP	Post-test Score	Time in Minutes
55	60	328
58	65	353
48	60	328
a	44	c
26	60	328
52	52	353
51	72	222
a	57	328
62	76	222
63	52	353

Public Display Heterogeneous Group

OAP	Post-test Score	Time in Minutes
27	64	190
31	85	190
44[b]	21	c
48	24	352
53[b]	15	352
38	24	287
36	24	287
47	69	d
30	63	310
58	27	c

Private Display Homogeneous Group

OAP	Post-test Score	Time in Minutes
55[b]	50	321
38	34	301
40	31	321
51	21	301
56	25	321
56	63	321
59	84	227
53	66	227
59	25	c
a	21	321

Private Display Heterogeneous Group

OAP	Post-test Score	Time in Minutes
44	21	311
46	24	311
a	18	311
38	31	283
39	24	283
55	24	c
48	51	287
45	12	c
40	45	260
a	21	260

---

a No OAP score available. Subject not included in attenuated sample referred to in Tables III, IV, V.

b Data eliminated randomly to equalize groups referred to in Tables IV, V.

c Unable to pass performance criterion.

d Unable to complete participation in experiment due to illness.

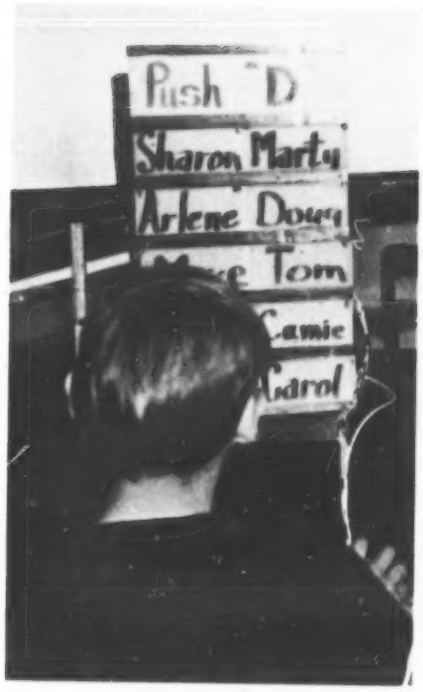


Figure 1. Display panel for groups receiving public knowledge of performance.

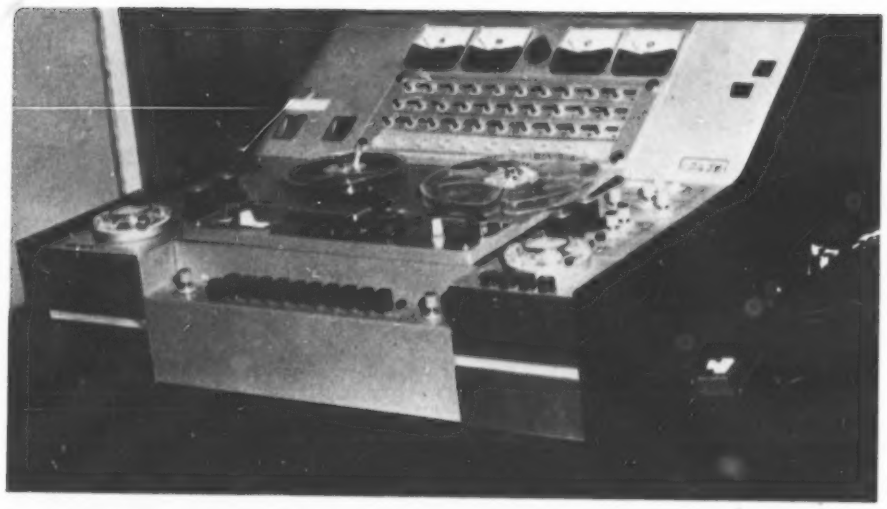


Figure 2. Edex Teaching System console.

Figure 3. Corrigan Teletest System student response station. (Smaller box is device to indicate readiness to respond.)

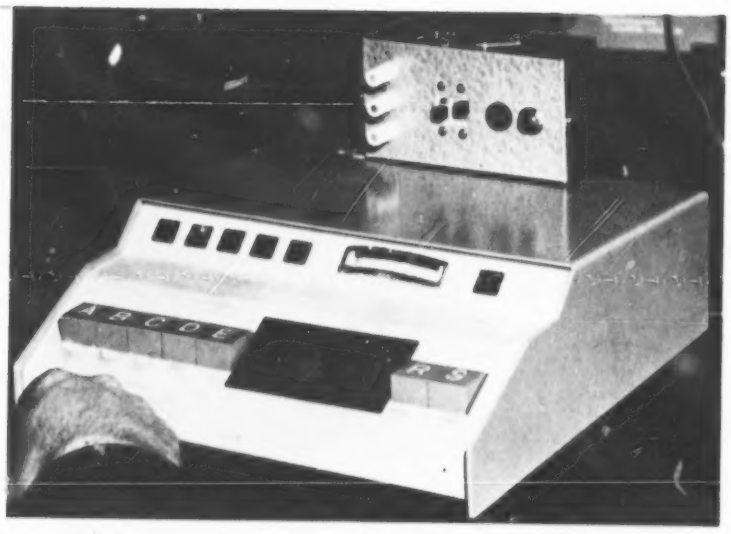


Figure 4. Corrigan System instructor console.